Constraining Uncertainty in Simulations of Tropospheric Composition: Implications for Predictions of Future Air Quality

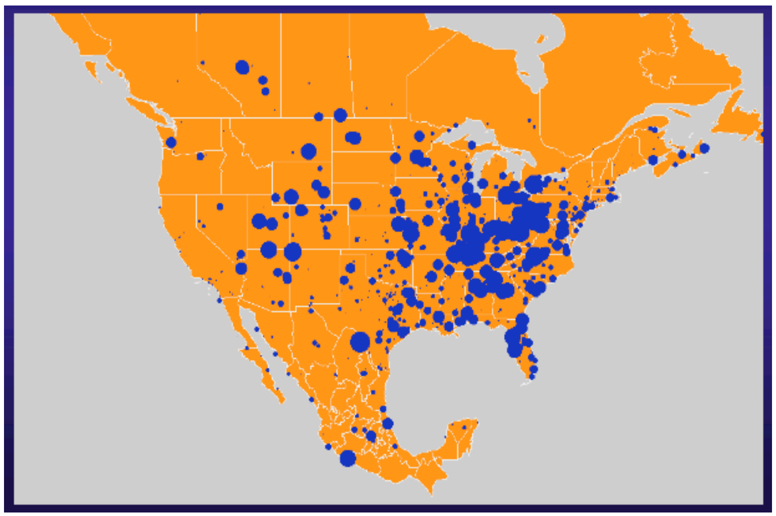
Task 1:

Parameterize Sub-grid Scale Variability of Ozone and its Precursors

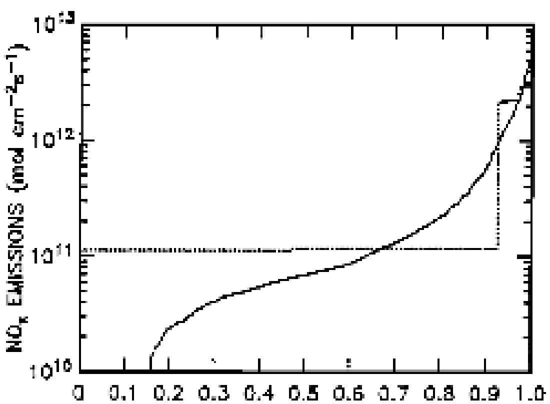
The Issues:

- Spatial Heterogeneity on sub-grid scales in emissions of ozone precursors
- Non-linear dependance of ozone production rates on precursor concentrations (turbulent diffusion is relevant)

- NOx and isoprene emissions typically not collocated - advection is relevant



NOx emissions from power plants



Example of cumulative distribution of emissions in a 480x800 km^2 area (Sillman et al 1990)

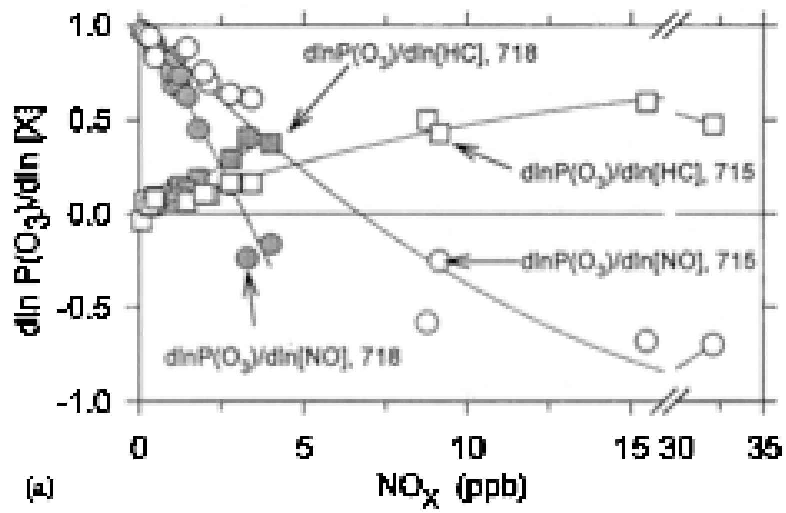


Figure 1. The relative sensitivity of O_3 production rate to [NO] and [HC], dlnP(O_3)/dln[NO] and dlnP(O_3)/dln[HC], as a function of (a) NO_x

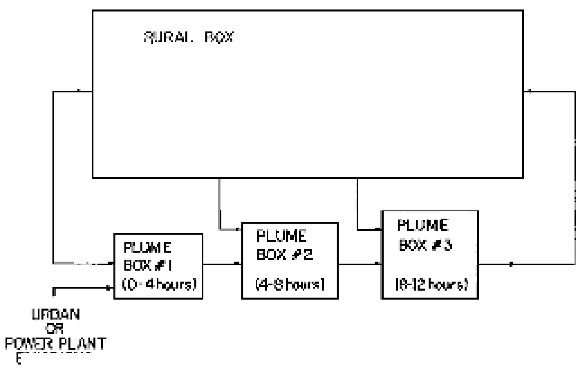
Symbols on panel (a) are results from steady state model calculations as identified in figure. Thin lines are a quadratic fit to data point:

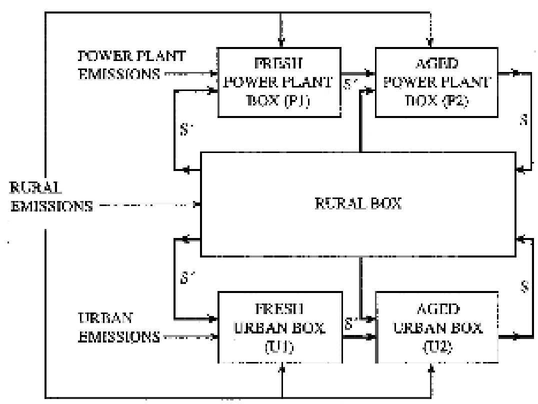
From: Kleinman et al, GRL 1997

Existing Solutions:

Plumes model (Sillman et al., JGR 1990, also Jacob et al., JGR 1993)

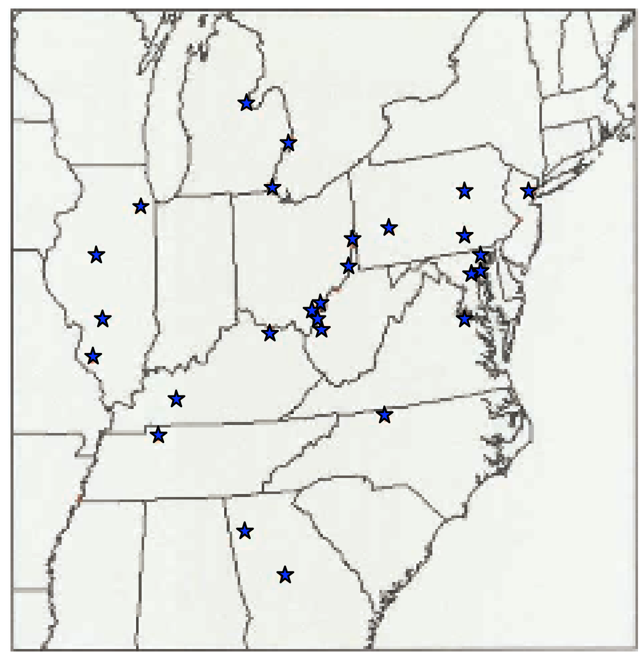
" … operates by dividing the model domain into sub-categories and calculating photochemical production and loss terms based on average concentrations of chemical species within each category. ….. average concentrations are calculated with satisfactory accuracy using only two plumes, a generic "urban" plume and a generic "power plant" plume.





Plume in Grid (PiG) treatment of point sources (Karamchandani et al., JGR 2002).

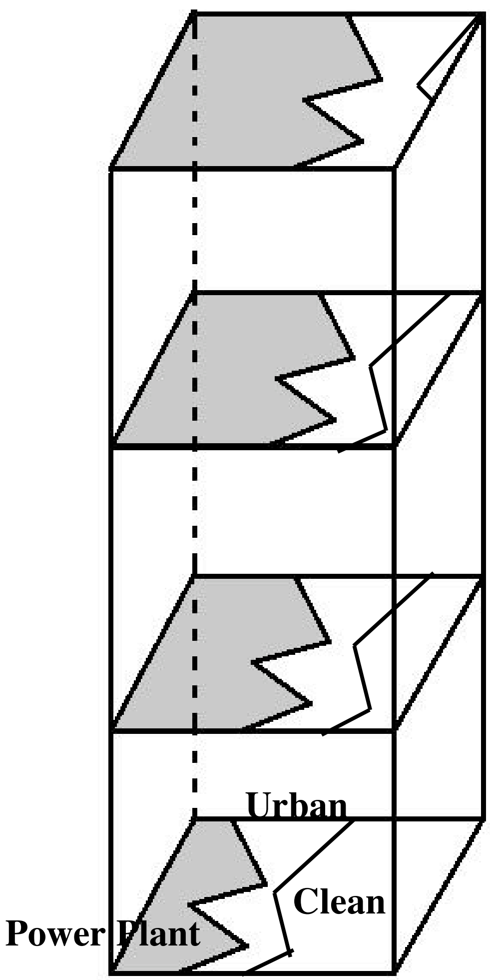
Each reactive plume contains its own chemistry which continues until 'maturity', a 2nd order turbulent dispersion, and the possibility of plume growth and interaction with other plumes.



Point source locations for PiG embedded in a 12 km model grid

Proposed “chemistry-mosaic” technique”:

Parameterize sub-grid scale variability in biogenic emissions, turbulent transport and photochemistry together to preserve the linkages among all these processes.



Grid boxes typically include a “power plant”, an “urban” and a “clean” tile (after *Sillman et al.,* JGR, 1990).

Each “chemistry tile” has its own level of emissions, chemistry, and turbulent diffusion. Fractional area is allowed to vary with height, is predicted based on diffusion, and can eventually be advected.

Evolution equations for each constituent are solved for each tile and for the grid box as a whole, using the technique described in *Molod* (Tellus, 2009).

Turbulent surface layer fluxes are currently computed separately over catchment of the *Koster et al.* (JGR, 2000) land surface model. A mapping from “catchment tile space” to “chemistry tile space” will be developed by overlaying biogenic emissions maps and catchments maps.